AIR COMMAND AND STAFF COLLEGE

RESEARCH AND DEVELOPMENT TESTING OF SPACE VEHICLES AND MISSILES UNDER SYSTEMS MANAGEMENT: A MORE FUNCTIONAL APPROACH

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A RESEARCH REPORT SUBMITTED TO THE FACULTY

May 1969

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ABSTRACT

This study reviews the use of the systems management/system program office (SPO) approach to the management of research and development test of space and missile vehicles. The SPO management concept uses an elaborate interdisciplinary organization wholly dedicated to the acquisition of one system. This study concludes that with very scarce resources (particularly experienced people and funds) and the present situation of many small systems that test economies and efficiencies can be realized by the use of special functional service staffs. They can perform many test planning duties in a centralized and single point-of-contact manner for all SPOs.

PREFACE

This study reviews the use of specialized functional service staffs to improve upon the traditional autonomous system management/system program office (SPO) mode of managing. Of direct interest was the test of space and missile vehicles on the Air Force Eastern and Western Test Ranges. The author has had seven years of direct experience at the Test Range and SPO organization in the field of documenting range test support requirements. This experience gave him an understanding of the workings and problems of the test documentation as it affects SPO, SPO parent organization, Aerospace Test Wing, and Test Range alike.

In mid-1966 the author was assigned as supervisor of a section at Air Force Systems Command's Space and Missile Systems Organization with the expressed job of improving the quality and timeliness of SPO test documentation. This was successfully done by centralizing the production of test support requirements documentation for all SPOs.

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CHAPTER I

INTRODUCTION

Research and development (R&D) is unassailable in its importance to, if not the keystone of, technological progress and military preparedness.[1] Without a continuing and vigorous program in R&D it is doubtful that the United States (US) can maintain a position of superiority or even parity with the Union of Soviet Socialist Republics (USSR) in the area of military strategy and capability. Yet much to the concern of many government and military leaders we find that the whole area of R&D appears to receive less than its share of attention. Prior to 1964 the United States spent more on military research, development, test, and engineering (RDT&E) than the USSR. Since then the USSR has spent as much, and probably more on military RDT&E than has the United States. The more surprising fact is that since 1962 there has been a steady decline in US military RDT&E expenditures.[2] Many possible reasons for the decline in US military R&D funds expended (i.e. Viet Nam War, pressing domestic problems, etc.) might be discussed

however, that is not the purpose of this paper. It suffices to say that R&D goes on in the United States at a decreasing rate of expenditure, our rate of inflation costs continue to rise, lead times for systems get no shorter, and we are still faced with military threats and other urgent and unanswered requirements. Some measure of the importance of R&D can be realized from the fact that during fiscal year 1969 the Air Force Systems Command (AFSC) will spend about 30 percent of the total US Air Force (USAF) allocations.[3]

Statement of the Problem

Even at reduced rates the US R&D program is expensive and it appears that R&D funds will be no more plentiful in the future, than they are at this time. From such a situation comes the problem to be discussed in this paper. It is this: is the cost of R&D testing of space and missile systems too high under the "Systems Management" approach and if so, how can it be reduced? It is obvious that this paper can only address a small facet of the total "lack of R&D funds" problem, the exact limitations will be discussed later.

Objective of the Report

The overall objective of the report will be to

recommend certain specific System Program Office (SPO) management or procedural changes that might reduce the total cost of testing space and missile systems. Such cost decreasing or effectiveness increasing suggestions will be based on a study of the testing philosophy, procedures, and methods under the SPO management concept. The report will have subobjectives of attempting to point out problem areas, that if alleviated could enhance the test program and hopefully result in a reduction of the testing cost.

Hypothesis

The hypothesis of this study is that: the overall cost of the R&D testing of space and missile systems under the SPO mode of test operation can possibly be reduced by modifying the traditional or, at least, present SPO way of doing his testing. In general this modification would be a move toward greater use of functional support in the R&D test cycle. Such changes might include:

a. Increased staff support in the preparations and review of all plans involving test in an effort to increase the overall quality of the plans.

b. Consolidated levying of all test support

requirements to insure timeliness, standardization, and correctness of needs.

c. Consolidated review of SPO need and use of test facilities to insure future availability and more efficient use of existing facilities.

d. Closer and improved SPO-Aerospace Test Wing relations to enhance test success and efficiency.

e. Cross-fertilization and exchange between SPOs for the expeditious solution of common problems.

f. Movement organizationally away from strict SPOs to a greater use of functional units (i.e. service staffs) to support several SPOs.

Limitations Placed on the Study

Many of the study limitations have already been alluded to in preceding sections. Limitations will be placed on the study to have a manageable subject in time and scope; therefore, resulting in more specialized recommendations than from a broader survey of the subject area. In summary, the limitations placed on this study are as follows:

a. Only R&D test matters will be considered.

b. Only the test of space and missile systems will be discussed.

c. The prime area of concern will be the policy, organizations, and management associated with this testing. Technical testing procedures and aspects will not be included in the study.

d. The review will cover only USAF [basically AFSC's Space and Missile Systems Organization (SAMSO)] programs.

e. The study will be restricted to unclassified aspects of the field.

Assumptions Used in Conducting the Study

Again, in order to have a manageable subject many assumptions as to the condition, and continuing condition, of the "real world" have had to be made. The following lists these assumptions.

a. Existing or present organizations involved in systems management and testing (AFSC Headquarters, SAMSO, Aerospace Test Wings, Test Ranges, etc.) will continue as presently operating into the future.

b. Attempts to cut the cost of testing will continue to be a desireable end and R&D funds will continue to be in short supply because of the Viet Nam War or other higher national priority programs.

c. The past importance placed on R&D to maintain

the technological growth of military capability will not diminish.

d. The future will not bring on the need to go into "crash" development efforts [i.e. the Intercontinental Ballistic Missile (ICBM) and Intermediate Range Ballistic Missile (IRBM) developments in the mid and late 1950s] to come up with radically new space and missile systems.

Organization of the Study

By necessity of this subject, this study will follow basically the descriptive analysis approach. A review of the literature on the subject of cost of managing (not just dollar cost in direct terms) R&D test reveals very little past study or voiced concern over such a problem. There has been a concern expressed on the short comings of the system management approach and this will be discussed. Until 1965 when large Viet Nam War expenditures started, R&D funds were not in such shortage as today, therefore, until recently the importance of this problem literally did not exist or have the magnitude it does today. The statement that such a problem even exists may be somewhat subjective and perhaps academic in that reduction of cost could be

said to always be an objective. Yet if it is admitted that a continuing need (and not a decreasing one) exists and that funds for such R&D are limited, then the objective or reducing cost of R&D test or at least attempting to get as much for the test dollar as possible, takes on a new, increased, and not so academic dimension.[4] In large, most of the evidence used in the study will be related from the direct experience of the author. This will be contrasted to good management principles, techniques, and fundamentals and just plain common sense to see if improvements in the R&D test situation can be made. The report will consist of five additional chapters. These will deal (in turn) with 1) a brief introductory discussion of what R&D and R&D testing actually involve; 2) a description of R&D testing in regard to the organizations involved; 3) highlights of present testing management problem existing in the SPO environment; 4) followed by an analysis of the problems and SPO or project management disadvantages in general; and 5) some conclusions and recommendations in regard to this analysis.

CHAPTER II

R&D TESTING OF SPACE AND MISSILE SYSTEMS

The purpose of this chapter is to outline the importance of R&D, R&D testing, and in general what is involved in the process. This overview or further introduction is deemed necessary to properly lay the ground work to place the problem being discussed as a subject of this paper in perspective and further explain the R&D testing situation. It is not the intent of this chapter (or this paper) to provide an exhaustive treatment of USAF systems management procedures as expounded in the Air Force 375 series of regulations and manuals. However the salient and necessary features of systems management will be related in this and the following chapter as they bear on the problem discussion.

Importance of Research and Development

As was indicated in the introduction, progress in all fields is largely dependent on a continuing and vigorous R&D program. Although this statement may appear to be self evident the USAF has seen fit to

express their concern over the continuation and importance of R&D as a matter of printed policy. Without resorting to paraphrasing this policy is offically stated for research specifically and R&D in general as:

> Conduct and support a broad and continuing research program in all areas of science and technology that hold scientific promise of eventual Air Force exploitation. Although research is not amenable to solving specific operational mission problems, it shall be oriented and controlled so that it will emphasize the search for knowledge in areas of greatest potential interest to the Air Force.[1]

> Continued improvement in our military capability is essential to sustain our military objective of deterrence and to generate the capacity for a flexible, swift and controlled response to agression. Continuity is essential to the successful conduct of R&D. Sustained R&D support will result in increased effectiveness and economies in military programs. The AF R&D program will explore the most promising approaches in science and technology. This program will be designed to maintain a superior technological base which will facilitate the development of military systems that can counter any threat to our national security. The principle tasks are to support the development of systems and equipment to satisfy current requirements and to provide a wide range of technological options for use in building a future Air Force inventory.[2]

From the above it is easily seen the importance that R&D has received at Headquarters USAF level. The Air Force of course does not perform R&D only, or just, for R&D sake but with the intent of answering an operational need or to progress the state-of-the-art across

the spectrum of development efforts. This is to say that depending upon the need and urgency of the need, R&D may fall into several categories (or a spectrum) starting with basic research followed by exploratory development, advanced development, engineering development, and operational system development.[3,4,5] This paper will deal with testing resulting or as a part of the latter three categories. Basic research, the prime purview of the Office of Aerospace Research (OAR) will come into the realm of this paper when tested as part of a space launch, i.e. OAR's Aerospace Research Support Program.[6]

Research and Development Testing

R&D testing is that program or undertaking which is intended to obtain, verify, and furnish data to be used in the evaluation of the R&D item in question.[7] The primary objectives of R&D testing briefly stated are to:

a. Verify accomplishment of development objectives.

b. Check fulfillment of system requirements.

c. Obtain as best possible an estimate of actual performance expected in operational use.

d. Discover any deficiencies or corrections

required before going into production.[8]

R&D testing is subdivided into five main groups according to the level of testing performed.[9] These as categories correspond to the degree of development toward a complete or operational system and are as follows:

a. Category I - Subsystem Development Test and Evaluation. This category deals as entitled with subsystems, that is, components which when put together make up the total system that the particular program will result in. These tests are, in the main, accomplished in the facility of and by the contractor which is on contract to design and produce the system. Such tests while of interest do not normally fall into the purview of this paper.

b. Category II - System Develoornent Test and Evaluation. Again as the name implies this category of test involves testing of the complete system. These development tests evaluate the integration of all subsystems in the operational (or final) configuration as much as possible. Data as required will be gathered in order to evaluate the performance of the system against required specifications. Category II tests are an Air Force effort and will be assisted by the contractor as

needed. It is this category of R&D test with respect to the launch of missiles and space vehicles that applies directly to this report. Such tests although not involving an actual launch, but in a support or associated role, such as: prelaunch tests, recovery operations, orbital support or support of a secondary (or "piggy-back" as they are often called) payload relate equally to the discussion of this study.

c. Category III - System Operational Test and Evaluation. Category III testing is the final phase of testing under the systems management concept and involving the SPO. Category III tests are performed by the operating (to be differentiated from the development agency as represented by the SPO) agency such as the Strategic Air Command (SAC) or Tactical Air Command (TAC) and involves the produced or operational system. Data is acquired to continue determining the capabilities of the system and to discover any deficiencies that must be corrected by the SPO in subsequent produced items. As might be correctly assummed the SPO role is one of observer and normally the management of Category III tests will not be of major concern as reflected in this paper.

d. Demonstration and Shakedown Operations (DASO)

and Follow-on Development Test and Evaluation. These last two areas of testing are listed mainly to complete the discussion development testing cycle. The first area is performed after Category III testing, by the operating agency, and to continue evaluation and training of operating personnel on the operational system. Follow-on testing is concerned with the revalidation of the system when updating changes have been made. Normally neither of these test categories will be of the magnitude interest-wise that category II tests were. In the event that the SPO becomes responsible for follow-on tests comments in this paper will apply.

Missile and Space Vehicle Testing-In Summary

At this point it is worth while to sum up the previous comments in regard to the testing of missiles and space vehicles. Since this paper will deal with test procedures and organizational arrangements in the next chapter, these items will only be briefly mentioned in this summary. The situation under discussion at this point is concerned with the test (launch) (primarily Category II) of complete missiles or space vehicles (boosters, suborbital probes, or satellites) by SPOs at or on one of the National Ranges. These ranges

include for the purpose of this paper the AF Eastern Test Range (AFETR) Patrick AFB, Florida, the AF Western Test Range (AFWTR) Vandenberg AFB, California and the Pacific Missile Range (US Navy operated) at Pt. Mugu, California. The actual act of testing follows a logical series of steps beginning with test planning to decide what measurements must be made, how many tests are to be conducted, the flight profile to be flown, and when the tests will be made. This planning is then translated into requests for support and submitted to the support agencies. The SPO is responsible for the preparation of support request documentation, following prescribed formats, and introducing it into the proper organizational channels. Normally day-to-day liason between the supporting range and the SPO is handled through the SPO's test representative in the Aerospace Test Wing located at the test site.

The importance of proper planning for the test and the timely and correct preparation of support requests is paramount to successful testing and the obtaining of data that allows for the intended system performance evaluation. When literally millions of dollars of prior R&D hinge on the success of a test it behooves all to insure that all possible steps have been taken to

maximize the outcome of the launch. The test in question is the culmination of many years of research, design, subsystem testing, and in general the proof or verification of all the prior planning. The seriousness with which the Category II test is approached must correspond to the payoff expected. It is obvious that to achieve this success all organizations must work in close harmony and understanding. Communication is crucial in that test support needs must be properly planned in the first place. They must be correctly stated and transmitted to the test support agency in a language and format that is standard and understood and then the test support agency must plan the actual support of the test. Each of these processes must be completed without a hitch if the importance of R&D and the minimization of test costs are to be achieved.

This overview and background of the importance placed in R&D and the culmination of the R&D in the test phase should have layed the ground work for moving on to a review of how the planning for test support is actually accomplished in the "real world". The following chapter will discuss the R&D testing of missiles and space vehicles in the systems management/SPO environment.

CHAPTER III

R&D TESTING IN THE SPO ENVIRONMENT

The intent of this chapter is to review and relate how R&D testing (primarily Category II for this paper) is accomplished with the SPO and systems management approach or concept. Although parts of this narrative may appear to be overly critical, such is not meant to overly criticize systems management but is given only in an attempt to improve on it. The object of the report is to highlight what the author feels are areas of concern in how the SPO is presently doing his testing business. Further elaboration on this belief will be provided and become obvious in this and the next chapter.

Systems management as used in the context of this paper, and in the Air Force in general, implies the process and use of a specific organization dedicated to the obtaining, acquiring, or producing of a specific system. Such an arrangement is usually superimposed on a more traditional line-staff and functionally oriented organization with the purpose of managing a specific item rather than several items simultaneously.[1] In

theory the systems management office (or product or project office as they are also often called in industrial circles) draws its manpower and much of its day-to-day support from the parent organization and at the completion of its project is supposedly dissolved and personnel are returned to their old jobs. The systems manager uses the interdisciplinary approach to manage all aspects of his system from planning to completion. He theoretically has all the types and varieties of talent and expertise at his fingertips, if not under his direct control. The reason that the systems approach was adopted was the necessity to cope with large complex high value projects that had aspects cutting across all functional lines and to many organizations outside the parent organization.[2] Within the USAF, systems management got its real start in the mid-1950s during the "crash" effort to deploy an ICBM system. With the ICBM we had all the aspects of a project that systems management was designed to handle. From the management efforts on the ICBM evolved the present systems management structure that makes up todays SPOs.

The remainder of this chapter will deal with those agencies and organizations that come together in the SPO systems management arena to perform and support R&D

testing. Of prime concern and to be discussed in the following order are the SPO, the SPO's parent organization, the Aerospace Test Wing, and the Test (support) Range. These along with the SPO's contractor(s) make up the R&D test team. Each will be discussed as to the part performed in the test mission and how they all fit together to get the job done.

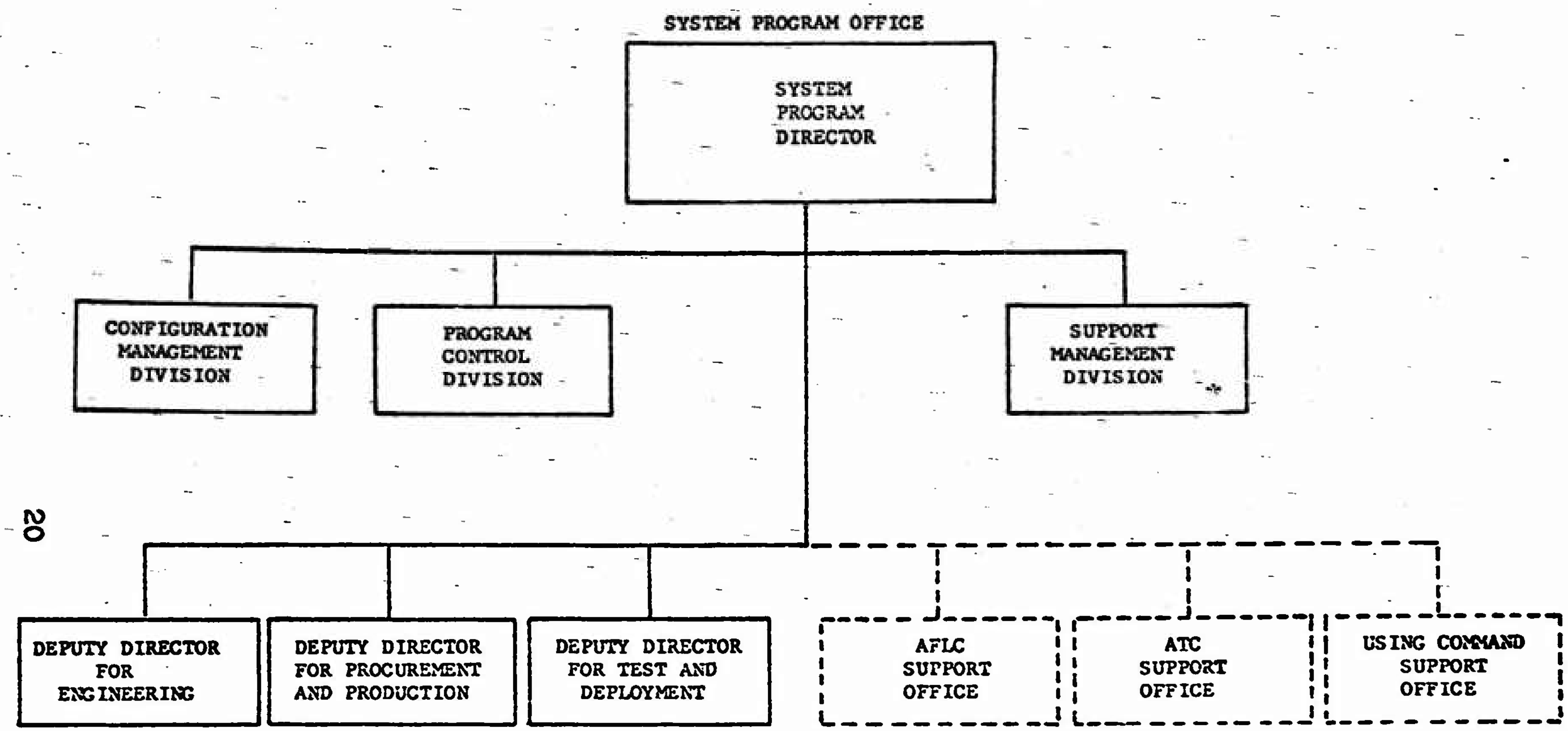
The System Program Office (SPO)

The SPO is the central organization in administering systems management in the acquisition of new systems. The SPO is first formed as a cadre during the early part of the conceptual phase of the weapon system acquisition cycle[3] when the Department of Defense (DoD) and Headquarters USAF have approved the approach and need for a new system.[4] The SPO cadre performs the early planning at this time that describes the system to be acquired. The Preliminary Technical Development Plan (PTDP) is one of their first documents that completely outlines the tests that will be performed. During the Contract Definition Phase the now fulfledged SPO selects the acquisition contractor and prepares more detailed system planning documents. The third phase, acquisition, is where construction of test hardware and writing of

test plans begins in earnest. It is during this phase that Category II testing is performed.

The organization of the SPO follows a standard prescribed pattern (see Figure 1) made up of engineering, program control, test and deployment, configuration management, and procurement and production offices. The SPO is to be manned only to accomplish essential planning, directing and controlling to fulfill approved program requirements throughout the program life cycle and will use staff support of participating organizations and other appropriate capabilities to the maximum extent.[5] Within this organization the Test and Deployment Division is responsible for the development of test plans, coordination of available test resources from test agencies, and management of Category II tests.[6,7]

All SPO produced development plans describing the complete system life cycle will have sections outlining the resources needed to support tests and a statement will be obtained from the support agency indicating his capability to support the tests in the desired time period.[8] When the complexity of Category II tests is considered it is evident that the establishing of sound test requirements at the outset cannot be over emphasized



* Restricted usage, AFSC approval required.

LEGEND

______AFSC Command Channel

------Other Participants

Fig. 1.--Typical System Program Office Organization

due to the possible impact that support will have on costs, schedules, and facility needs.[9] Specific policy has been published on the development of test support needs, this is:

> In the interest of economy, existing test facilities, test equipment, and capabilities will be used where possible, instead of developing new facilities, test equipment and capabilities. To the extent practicable, the most realistic operational environment attainable will be used for development testing. Testing will be consolidated when feasible, to avoid duplication. Test data available from other sources or obtained during early stages of development testing will be used to the maximum.[10]

Test needs must be intelligently evaluated, particularly for construction, due to the lead time needed for development or scheduling of government facilities. Capabilities and facilities that exist for testing must be known and used. The SPO has been instructed to look to his parent organization for assistance in planning for test facility requirements.[11]

Once the SPO has decided what his test support needs are he must document his requirements to the test support agency, in this case Category II tests to be supported by one of the National Ranges. Each test requirement must be documented for good management, and the format of the test documentation should be standardized to include all essential data.[12] Each range has a

series of time phased formats (normally referred to as range requirements documentation) that are used by the SPO to display his requirements for test support. In the early phase of program planning the document submitted is brief and introductory in nature. The first document is called the Program Introduction (PI). This document alerts the range that future test support is likely and provides them information to gain some understanding of the test support needs. Once the test program becomes better defined a more detailed document, the Program Requirements Document (PRD) is produced and forwarded to the range for their review and preparation of equally detailed range test support plans. The PRD will be a direct reflection of test data, facility and other support needs as listed and outlined in test plans produced by the SPO's contractor. The final phase of test support requirements documentation is the Operations Requirement (OR). The OR is issued just prior to the test and contains an even greater level of detail than the PRD.

Prior to mid-1966 the SPOs in SAMSO were preparing, or having prepared, PIs [or Planning Estimates (PEs) as they were called prior to 1968] and PRDs on a SPO-to-SPO basis, some by the SPO, some by the acquisition

contractor, some by a not-for-profit contractor such as the Aerospace Corporation, or even some at the field level of the Aerospace Test Wing at the launch/test site. Test support requirements documentation prepared on such a decentralized and haphazard basis, although conforming to the systems approach of each SPO doing his own job in his own way, lent little to standardized, timely, and high quality products. Very little thorough staff review was made of system test plans, development plans (i.e. PTDP and subsequent documents), and other test requirements or test facility plans. The following section will describe an experimental office that was set up to make a radical change in this old way of performing test planning and to try to work out some of the just related problems.

In leaving the SPO momentarily let it be said that each SPO operates enlarge independently of other SPOs. This is basically intended yet if one considers the mutual problems that similar (space or satellite) SPOs face then it is apparent that a lack of cross-fertilization and duplication of effort could result. Each SPO develops what is called in the business as "tunnel vision", he only sees and drives to his own objective. As will be described later, this lack of across-the-SPO

supervision or liaison by staff or line alone can in many instances lead to inefficiences that the very SPO was set up to avoid.

The SPO's Parent Organization

In the case in study the SPO's parent organization is SAMSO. SAMSO is an equivalent of a product or development division and operates under the command of the AFSC. This section will discuss SAMSO's involvement (over and above the SPO) in the test process. An organization chart of SAMSO is included as Figure 2. On this chart certain key SPOs and other offices have been highlighted for use with the following discussion.

The mission of SAMSO is as follows:

> Plans, programs, and manages system programs to acquire qualitatively superior space and missile systems, AGE and other subsystems, and related hardware; provides for the activation and alteration of missile sites and ground launch facilities; performs the functions of launch, on-orbit tracking, data acquisition, and command and control of DoD satellites; and effects recovery of various space packages.[13,14]

It might be assumed that SAMSO manages the SPOs assigned to SAMSO, yet in practice each SPO is quite autonomous and ineffect answers literally directly to the DoD Deputy Director of Research and Engineering (DDR&E). There is no doubt however that the reason for

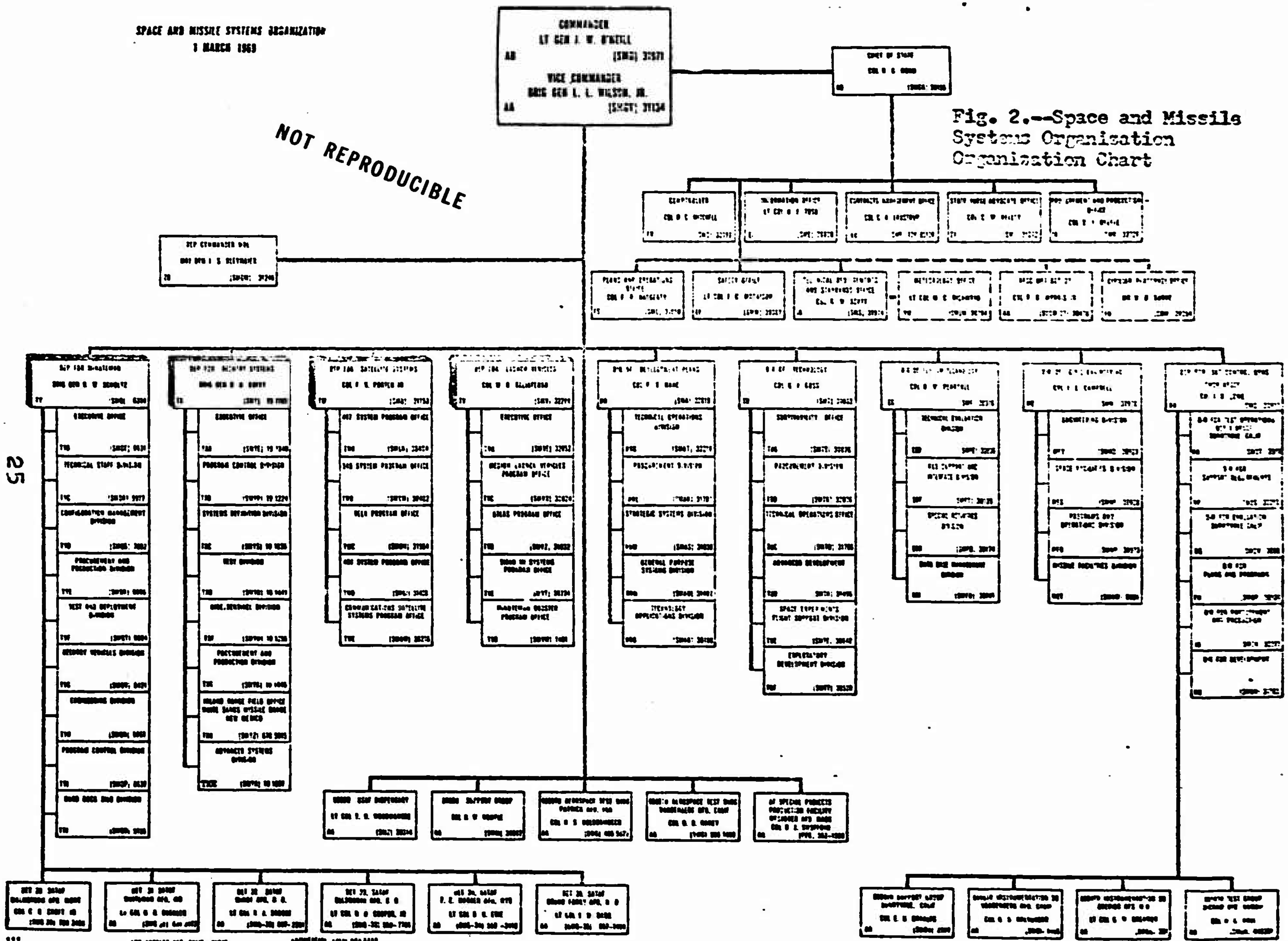


Fig. 2.--Space and Missile Systems Organization Organization Chart

SAMSO existence is to support the SPOs from the system concept formulation by the Director of Development Plans, launch operations by the Aerospace Test Wings, to the monitoring of construction of new test facilities by the Director of Civil Engineering. Policy reads in System Program Management Procedures that: "All organizational elements within or functionally related to the SPO will adhere to and support the implementation of the system program management process."[15] This policy of parent organization staff and line support of the SPO is further amplified in AFSC's System Program Office Manual. Of specific interest and application to the discussion in this paper is the suggested use of a service staff to perform pooled tasks for all SPOs. The following lists this guidance.

> AFSC Systems Division Staff Organizations. Division staff elements are those which have responsibility for providing advice and assistance to the commander. In relation to the SPO, staff functions are often two-fold: to advise and assist the SPO regarding policies, criteria, methods, and procedures developed locally or directed by higher authority; and <u>to perform specific functions for or in support of the SPO where capabilities has been pooled to serve division wide</u> and must be responsive to the system program director. [under line added]
>
> AFSC Systems Division Line Organizations. Division line elements are those which have the responsibility, authority, and

accountability for primary division objectives. In AFSC systems divisions, the line elements consist of the SPOs and certain specialized technical functions such foreign technology and civil engineering. These latter organizations furnish specific operational support to the SPOs and assure education in the areas of their specialty.[16]

If the SPO is to accomplish the complex task of system management the System Program Director (SPD) and his SPO personnel must look to many outside agencies (outside the SPO) for support. Only by continual cooperation and joint effort between the SPO and support agencies can the SPD achieve his mission.[17]

The SPO's parent organization will normally have a wealth of background and depth in matter of great importance. These may be in solutions to technical design problems, support in research areas, and special knowledge on procedural matters pertaining to systems management itself. It is such an area that the SAMSO commander organized and staffed an experimental division within the Plans and Operations Office to oversee the functional area of SPO R&D test of missiles and space vehicles on the National Ranges.

As a test case this division (originally called the Test Operations Division and recently changed to Operational Systems Development Division) was given the job

of reviewing of all SPO test plans and development plans in the area of range requirements and National Range test support. To insure that its guidance was carried out the office was also charged with consolidating the physical preparation of range test support documentation (PIs, PRDs, and all revision thereto).[18] The office was also charged with staff review of all range (missile flight) safety matters and range instrumentation needs. In short this small office (approximately ten officers and two typists) was intended to provide a service staff in a functional area (range test support) for all SAMSO SPOs. The intent was to centralize the function, standardize procedures, and provide for SPO and range alike one office or a central-point-contact for all range matters.

As might be assumed the relinquishing of the work previously done by the SPO (or elsewhere as previously stated) was not done without resistance to change. One-by-one the various SPOs were essentially "won over" when they found that the service was being conducted in their best interests, that they could expect timely service and that the product was consistently superior to what they had under the previous mode of operation. The case of the preparation of range test support requirements

documentation (of which the author was directly in charge) involved the collation from whatever sources available, test requirements that were validated by the SPO then displayed onto the proper range documentation format. In approximately two years of work (mid-1966 - mid-1968) all SAMSO SPOs were incorporated into this procedure and over 40 different programs were being serviced. The degree of success that this office achieved is difficult to measure, yet it was established that documentation of a higher quality (accuracy, validity, and standardized format and terminology) and more timely nature (shorter preparation time or with more time prior to test) was being produced. Similar advantages were being accrued in the areas of range safety and test instrumentation.

At this point it is best to leave this particular discussion, as more will be included in later chapters, and move on to the final two members of the test team. These two, the Aerospace Test Wing and Test Range are most important since they actually become involved in the actual conduct and support of the test.

The Aerospace Test Wing (ATW)

The ATW is the prime SPO test representative at the

test site (Test Range). The only reason for the ATW's existence is to provide on the spot day-to-day field management of the actual hardware tests. An organizational chart for the 6555th ATW located at the AFETR is shown as Figure 3. The other ATW, the 6595th ATW, is located at the AFWTR and has similar duties and is organized in a corresponding manner. The 6555th ATW is charged with the launch of all Minuteman ICBMs, Atlas boosted payloads and Titan III boosted payloads fired for the USAF on the AFETR. Referring to Figure 2 it is found that the 6555th ATW is organizationally in the chain of command under SAMSO.

In the area of interest of this report it is found that the 6555th ATW also uses a single or central-point-of-contact to receive (primarily from SAMSO) notification of new test workloads. When the SAMSO Test Operations staff office prepares range test support requirements documentation on an approved SAMSO (SPO) program it is signed by the SPO Test and Deployment Division. This signature certifies that the requirements stated on the document are valid. The requirements document is then forwarded to the 6555th ATW Plans and Requirements Office (the ATW central-point-of-contact) for further staffing by the applicable launch division before

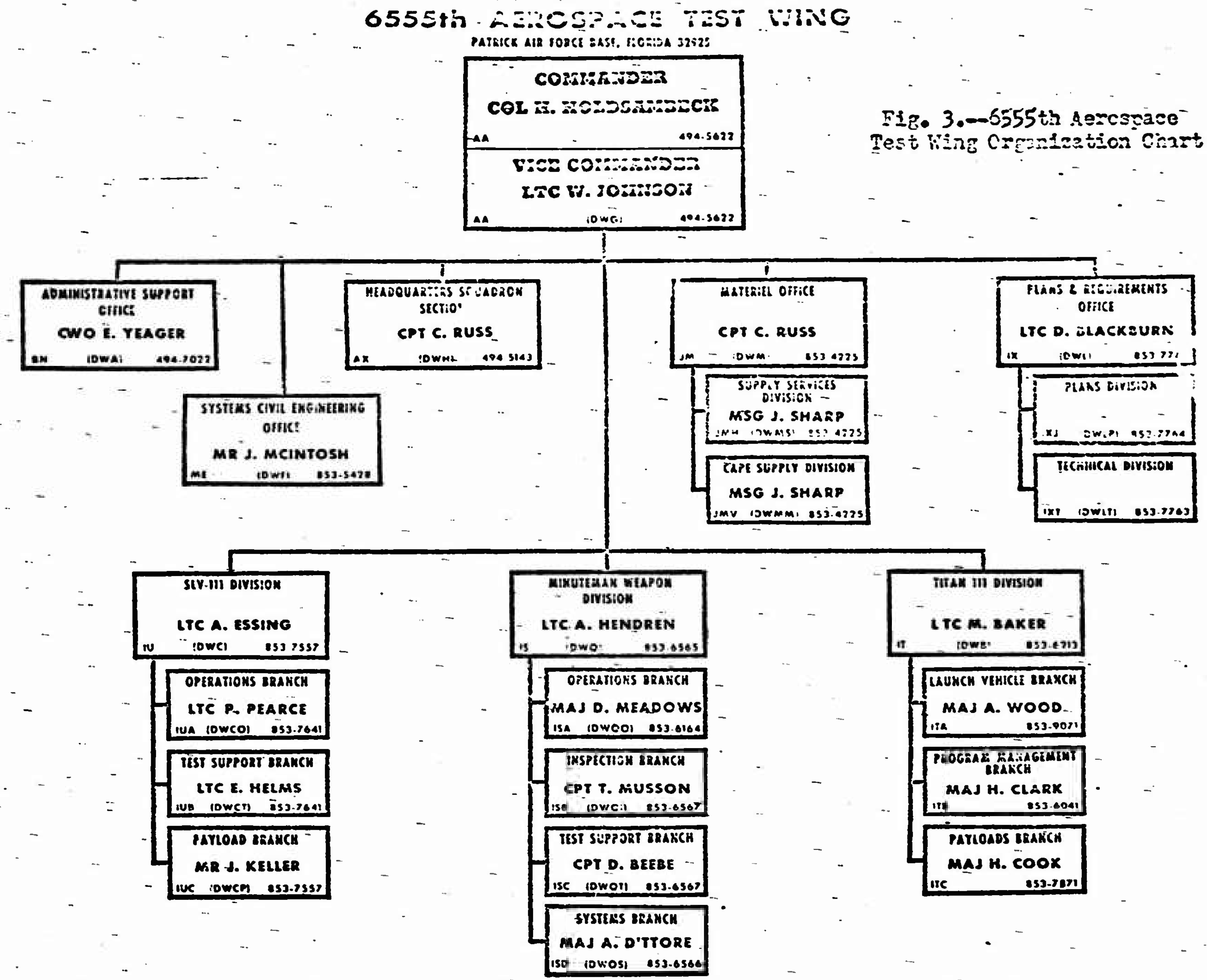


Fig. 3.—6555th Aerospace Test Wing Organization Chart

submission to the Test Range for support planning. Further investigation into the 6555th ATW organization reveals that both the Atlas and Titan III launch divisions serve several payload and booster SPOs located at SAMSO. Thus between the ATW Plans and Requirements (staff) Office and the launch divisions we find a further movement from the strict SPO dedicated or systems management approach to a common service or more functional approach.

The Test (National) Range

To cap off this discussion of the major organizations involved in a test of a space or missile system the Test Range will now be reviewed.

The Test Range is essentially a facility to provide a location to prepare and launch the particular test vehicle and to gather whatever test data is required to evaluate the test and the test item performance.[19,20] The ranges operate numerous sensing systems (radar, telemetry, optics, etc.) which gather the desired data for delivery to the SPO and his contractors. The types and degree of support of the test is as requested in the previously discussed test support requirements documents (PI, PRD and OR).

The Test Ranges also operate on the central-point-of-contact principle for test workload coordination. Referring to the organization of the AFETR (Figure 4) and the AFWTR (Figure 5) the Plans and Requirements (staff) Office is the initial contact point at each range for new work (test support requests).[21] At the AFETR responsibility for the PRD and OR responses shift to the Directorate of Range Operations, still maintaining the idea that at any point in the program life cycle there is only point of contact for the requirements. At the AFWTR the Plans and Requirements Office prepares the PRD response and the OR responsibility is transferred to the Directorate of Range Operations. Regardless of the differences, the principle of single-point-of-contact for each situation is retained.

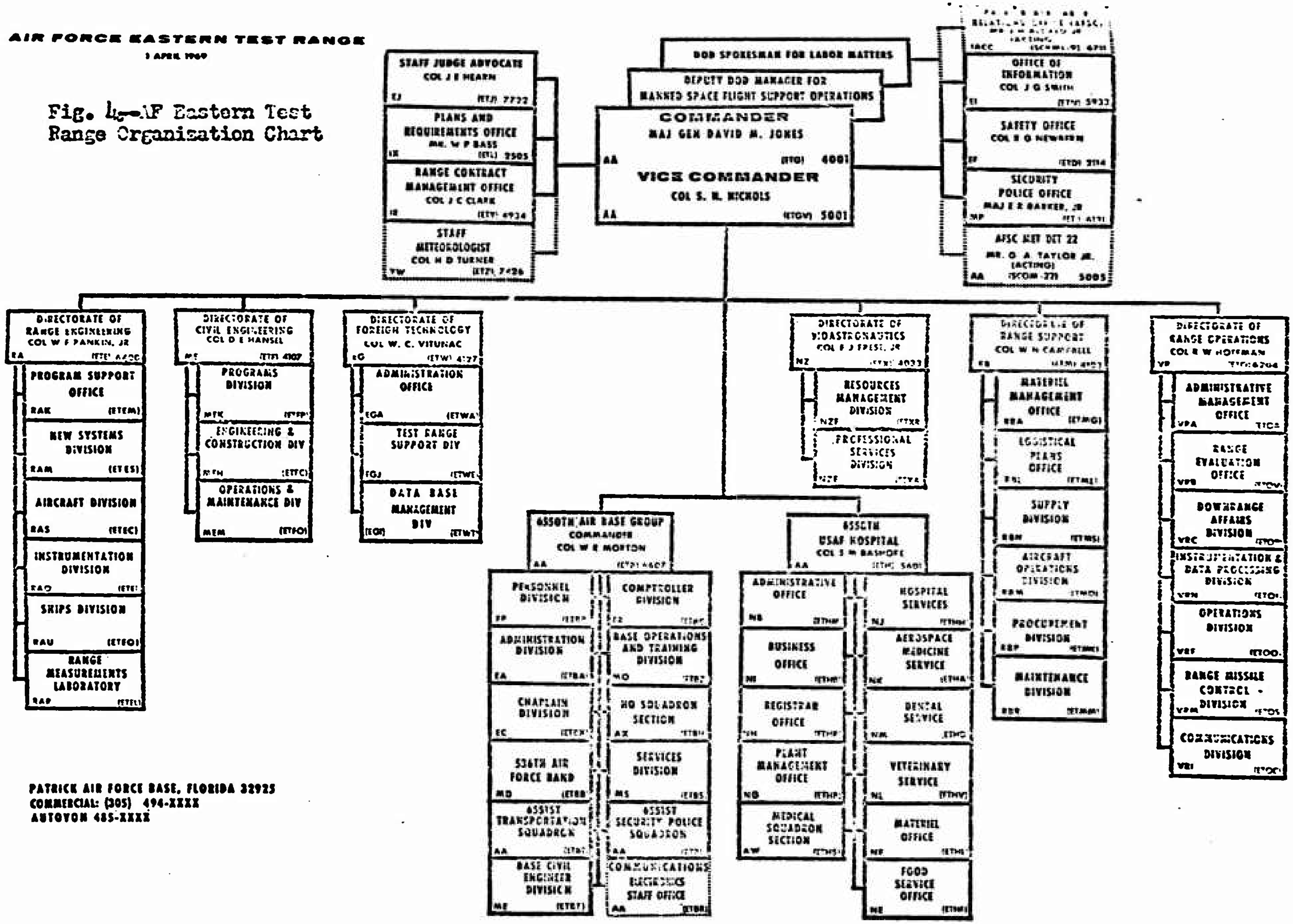
At each of the offices (or points-of-contact) discussed above a consolidation of like jobs for all test agencies (SAMSO SPOs/ATW being just some) has been performed. This action simplifies procedures and adds much efficiency over any operation that would be fractionated by SPOs.

The Test Team in Perspective

The object of this chapter has been to trace the

AIR FORCE EASTERN TEST RANGE
1 APRIL 1969

Fig. 4—AF Eastern Test Range Organization Chart



PATRICK AIR FORCE BASE, FLORIDA 32925
COMMERCIAL: (305) 494-XXXX
AUTOVON 485-XXXX

AIR FORCE WESTERN TEST RANGE
VANDENBERG AFB CALIF 93437

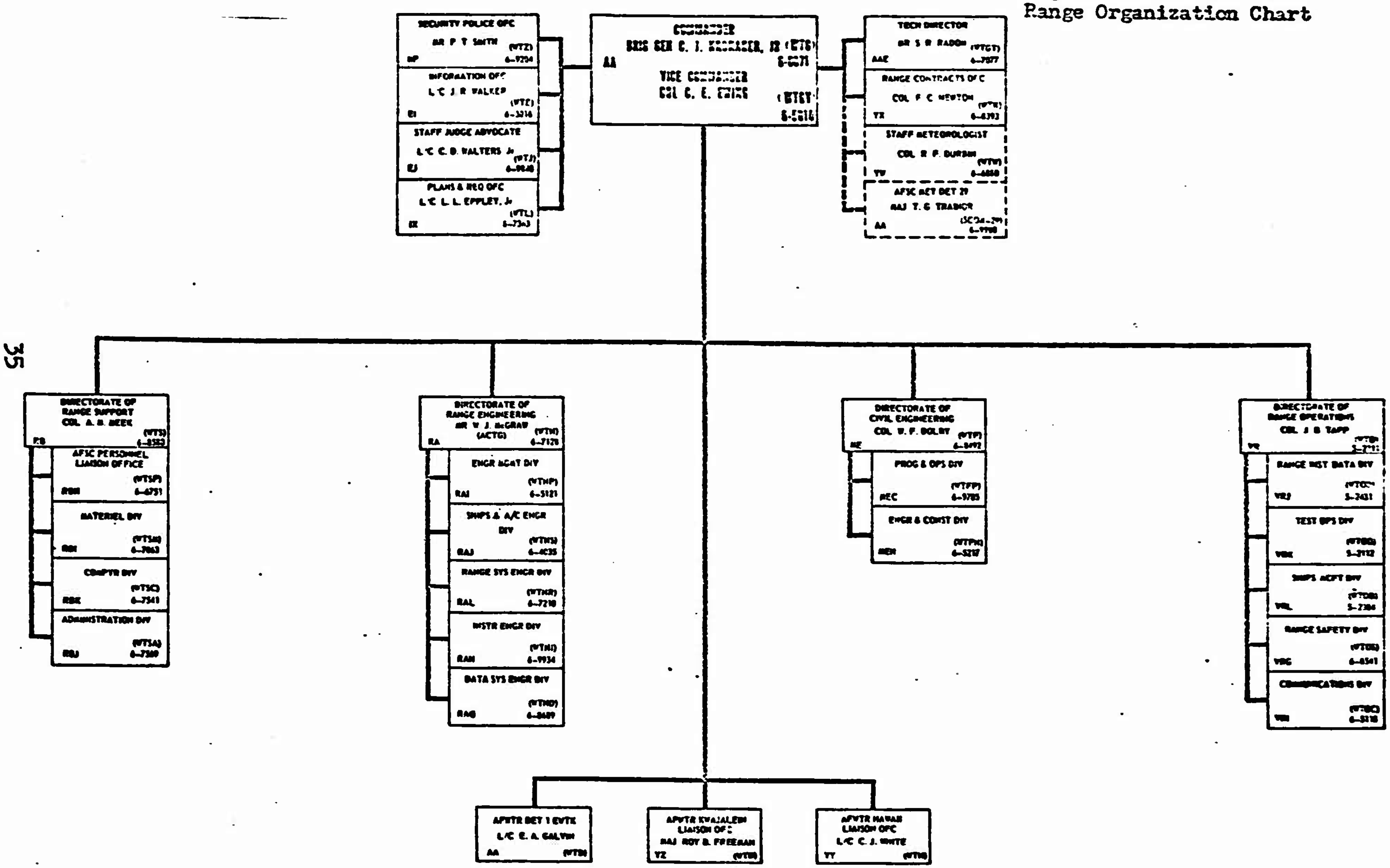


Fig 5.—AF Western Test Range Organization Chart

path taken by test range support requirements documentation from SPO, through the SAMSO staff, to the ATW, and finally to the Test Range. The prime thought at this point is that SPOs are organized basically as almost autonomous organizations in contrast to their more functional parents and supporting agencies. When the principle of single-point-of-contact is applied at the Test Range and ATW, then the SPO parent is faced with a problem in matching the field to prevent the confusion of each and every SPO going separately to the field for each test requirement action. It was found that by removing certain functional jobs from all SPOs and consolidating them at the staff level of the SPO parent organization that many benefits of standardization, quality, and timeliness resulted. From almost an important point of view the single-point-of-contact principle was extended one more step and in effect the SPOs had one voice (channel) to the ATW and Test Ranges and vice versa the Test Ranges and ATWs had one voice to the SPOs in these particular test matters.

With these and the previous chapter as background and explanation of the test situation the next chapter will address additional management problems encountered in the SPO test environment.

CHAPTER IV

SYSTEM PROGRAM OFFICE TEST PROBLEM AREAS

The object of this chapter is to continue the discussion of the traditional SPO mode of test management and to describe certain continuing problem areas associated with that method of doing business. Again it should be stated that the over-all intent is not to "tear down" SPO or systems management but hopefully to identify certain areas which if changed could increase effectiveness or lessen the cost of test operations. As has been implied before, the accomplishment of these two objectives (increased effectiveness or less cost), particularly the latter, may be very difficult to measure, especially in dollars and cents. The object is to in general devise a better way that has less snags and has a greater over-all chance of consistantly being successful.

Systems management is no doubt here to stay, as it probably should be, and will probably continue to be used in applications where it is best suited, its over-all advantage of clarity of purpose (mission) is

difficult to match on programs of major magnitude.[1] Yet every organization or management arrangement can be improved upon and the perfect one has yet to be devised. The following problem areas (in only the small area of test) have been taken from the author's daily contact experience over seven years with SPOs from the vantage point of the SPO's parent organization (SAMSO) and the Test Range. Many of the problems in the following discussion overlap yet they will be discussed separately to emphasize each particular point. The greater management implications of these and the general SPO/systems management concept will be deferred to the following chapter.

A Costly Way to Manage

The SPO form of management is inherently an elaborate way to manage and acquire systems as it spares little in the extent of the organization. The SPD has great authority and has a SPO which is equipped with an extensive array of talent (engineering, procurement, administrative, scientific, management, etc.). When used in its unadulterated form the SPO is extremely autonomous in its striving to complete its assigned task. The SPOs as originally intended relied on few outside of its own talents and that of contractors

under direct control. Policy presented in this paper of a more recent nature has been to modify the SPO's independence and place greater emphasis on review and support by other levels of management and functional areas of the parent organization.

As mentioned before, systems management (and the SPO concept) first came into its own was during the "crash" "money's-no-object" missile development effort of the mid-1950s. Granted, when we have a highly urgent need of such magnitude, we will and must do anything and everything to find a solution. If the method doesn't include the niceties of management and disregards costs in trade for effectiveness, then no doubt it was necessary. Such a need is not now before our SPOs and to make it worse the country seems ill prepared to stand the cost. As explained by General B.A. Schriever, it appears that the short-cut costly route (with little or no higher headquarters staff review) once followed (circa 1950 s) will be used on a very limited basis in the future.[2,3]

This problem of lack of funds to support several small programs (or SPOs), as we see in the SAMSO mission, also falls into the area of: do we have enough resources to set up and fully support on an individual basis this

many SPOs? It would appear that full-blown SPOs, for many small programs, are potentially wasteful especially if there is any commonality between the programs, e.g. common launch vehicle, flight plan, launch range, etc. When small SPOs (or small programs) are set up, they inherently have few people assigned. The lack of people to be expert in every area that a SPO is involved creates difficult conditions. Each man must double up in duties and probably can't do any justice, he just has too little time to learn all the jobs.

Uncommon Solutions to Common Problems

The program-by-program approach, which is what separate independent SPOs imply, has a definite problem in communication between SPOs. Cross-fertilization in technology must be used if we expect to apply a successful solution in one area to another. Within the existing SPO structure too little "crosstalk" occurs between SPOs. There is a great dependence on people, their experience, capabilities and that of any contractors there at the moment. Each test program tends to go its own way with too little interchange of data and experience.[4] The use of functional staff or line organizations to either supervise or perform the work in areas of interest

common to all SPOs can do much to alleviate this problem.

The author has personnally witnessed different SPOs working on similar programs (i.e. same orbit, same booster, similar level of technology) and having essentially the exact same technical test problem; one was proceeding in one manner, the other didn't know what to do. Even though the two SPOs were physically less than 100 feet apart the author became the technical go between. It is not to difficult to imagine a very costly and potentially test failure developing out of this lack of getting together over common test problems.

Lost Expertise

Every job has its aspects that are routine and the same as the last job. The R&D field in general appears, to the newcomer from the operations field particularly, that there are few routine operations, no standardized procedures, and a condition that is less than clearly structured. Although this is not entirely correct it seems so to most and having been in one R&D organization does not provide immunity to the feeling. The breadth of different activities in the R&D field are staggering and it takes a new man on the job (regardless of background) some six to twelve months to really gain enough

understanding to become productive. The rapid rotation of people in and out of assignments compounds the problem of an already less than clear situation.

Each time an experienced man leaves the SPO his expertise is essentially lost. The new man has little to fall back on unless it be the office files or, if he is lucky, an office member who has the knowledge and time to help him through the rough period of getting oriented. Most people learn the hard (and time consuming) way, via mistakes. They come into a SPO, are given a task and with their complete lack of knowledge and procedures have a very difficult time. The test function is very critical in that numerous outside agencies (such as discussed in the previous chapter) have a myriad of procedures, forms, regulations, manuals, etc. that must be used efficiently if test effectiveness, or reduced cost is to ensue. It is impossible for an inexperienced employee to know who to contact, what forms to fill out, what capabilities each test facility has, and how he should display test requirements to get his test program going. It is the author's experience that the man in the SPO Test and Deployment Division with adequate experience in arranging for test support is the exception.[5] The advantage of

use of continuing staff support in this case is obvious.

The Lack of Quality Test Documentation

As was discussed in Chapter 3 the majority of offices receiving test support requirements documentation downstream from the SPO (i.e. AFW and Test Range) have a central or single-point-of-contact. To ease their job of review and proper staffing of responses or support plans several things must be strived for in input documentation quality. When documentation is prepared on a SPO-by-SPO or decentralized basis for program-by-program it will rarely result in a smooth standard product. Each SPO will use different terminology, format, ways of presenting material, and level of detail provided. It is difficult to insure timeliness of submitting the documents to the test support agencies since the SPO may be busy elsewhere with his meager manpower.

Going back to the original statement, to get good support the SPO must submit good requirements. The test agency must know exactly what is asked or wanted, it must know that if a certain requirement is present it will be displayed consistently on a certain page in a standard way and terminology. The use of correct

procedures and channels of organization with necessary coordination is just good management, yet such cannot be assured if inexperienced people on a decentralized and uncontrolled basis are involved. The inexperience factor shows up in test documentation quality especially in the situation that many SPOs just have little real knowledge or understanding of their actual test requirements. As a result they express them neither correctly or completely for the total test support needed. The lack of time and SPO ability shows up in a failure to communicate needs in a correct and efficient manner. Minimum support consistent with test objectives must be asked for, not inflated or unrealistic needs. Again the use of an office to perform this (a common) service for all SPOs, to insure quality, timeliness, standardization, format, procedures, terminology, and correctness and completeness of test requirements can prove very beneficial. Such an office can easily identify common requirements between similar programs and express them in exactly the same way.

Lack of Communication Between Units

When SPOs deal on a completely fractionated basis on their test program it may benefit one SPO but the

overall effect for all agencies in the test team may be less than optimum. The lack of ability and time of SPO test personnel to properly address their test needs and support impedes the flow of communication. To communicate in terms of testing efficiently one must "think test" not just program. The SPO tends to underestimate the importance that proper (or improper) work on his part in the test requirements area will have in effect on the ATW and Test Ranges. The lack of interest on the SPOs part in keeping the test agencies informed creates a tense, non-cooperative atmosphere which does little to improve the test support planning or future dealings.

The test team must work on an extremely close basis if to be really effective. Yet this mutual trust based on continual faith, honesty, and belief is not always in evidence. The "not-invented-here" approach is unacceptable if the SPO's test is to be truly managed in an efficient manner. People must talk together often and long to work out the details of support. The formal documents must be the best possible but they form only the start and a place to meaningfully begin discussion. The use of dedicated personnel oriented to test and all the minute details on a day-to-day basis

for all programs is one approach to developing the interest to bridge successfully the SPO to test agency gap.

Too Many People in the Act

This last section is an attempt to highlight in another way what has perhaps been implied before. When each SPO or program makes all his own contacts with test support agencies and on a continuing basis, the test agency is inundated (or perhaps not contacted at all) by a different man for each program. Each may be as inexperienced as previously implied and talks in a different language, besides not really understanding what he needs or who to go to.

The use of a small central-point-of-contact simplifies the number of people that the ATW or Test Range need contact to inquire about any program. It relieves the problem of the number contacting the test support agencies as well. The language will be standard and the continuity of effort will result in improved communications requirements documentation product and hopefully the forthcoming support.

Problems In Summary

This section has attempted to emphasize the common

problems observed in the SPO testing environment. Most test problems are brought about when SPOs operate on a program-by-program basis with inexperienced people. Another major factor causing trouble is the situation where the SPO is too small to warrant a large manning yet all functions must somehow be accomplished. The lack of understanding in depth of how to arrange for test via range test support documentation can cause great confusion. This is easily avoided with personnel that are knowledgeable of proper procedures. The functional support staff has been suggested as one possible help in this area. This office has been discussed in the preceding chapters and will be further expanded upon in the following chapters. The next chapter will specifically cover a management treatment of systems management.

CHAPTER V

MANAGEMENT'S VIEW OF SYSTEMS MANAGEMENT

This chapter will review some of the thoughts of experts in the management field on the use of the systems management approach. The particular intent will be to relate what others see as the weaknesses or problem areas that one must be aware of in using systems management and their suggestions on how they can be alleviated or minimized. The chapter will be divided into two main sections the first concerning division of work with systems management and the second dealing with the use of special functional staffs.

Systems Management and Division of Work

Many organization and management experts consider the principle of division of work as one of the most important concepts when analyzing or setting up organizations.[1] Using this concept of division of work or departmentalization involves bringing together under one head a large amount of a specific kind of work and makes it possible in each case to capitalize on the most effective work separation and specialization.

Such an arrangement also fosters economies of the maximum use of mass production techniques arising not only from the amount of work done or that the work was similar but of most importance that the work was performed with the same technique, materials, procedures, and motions.[2]

Organizations erected on the basis of purpose (systems) have the built in danger of not using the most up-to-date techniques and specialties because there may not be enough work of a particular technical variety to result in this efficient subdivision of work.[3] The use of functional or specific process departmentalization normally takes advantage of the potential of specialization to a greater degree that does a "purpose" organization.[4] Subunits of a system or project organization may be submerged to the point that they lose their effectiveness. This is particularly possible when they are too small to devote time and people in an adequate amount to each and every problem.[5] The large mix of different areas of expertise necessary to sustain a product or system approach places a definite limit on how much arrangement or rearrangement of jobs can be made to equalize work loads between people. The problem of over using people may be contrasted to the

danger of duplication of facilities or underuse of equipment within a system or product organization.[6]

Communications is a continuing problem in all organizations but the lack of it can be particularly felt in the product organization. The lack of discipline (like job) tie between people in different projects organization (in the same overall organization) results in little cross-fertilization among them. This situation of working somewhat in isolation, and with apparent little concern for keeping current on or in contact with others in the same field but working on different projects, may well be the key limitation of the product/project structured organization.[7] Communications of course should not be limited to between disciplines. There is also a problem of facilitating communications between the project man and any other assisting unit within the parent organization. Since the project manager cannot afford to have a complete staff (due to the limitation of keeping them busy in their specialty) he has the obligation to keep open lines of communication and coordination with all supporting units.[8,9,10] The need for centralized communications in a diverse and decentralized (project oriented) organization in the technical area cannot be overstressed.

Project autonomy is an other danger often expressed by writers in management. When a subunit is given a great amount of autonomy this may develop into such independence from the parent organization that the best interests of both are not being served.[11] Close attention to this perhaps rare, but potentially unfortunate situation should be maintained.

An interesting disadvantage of the product structured organization involves the multiplicity of external contacts that may be necessary if there is no centralization of certain functions (such as sales). This condition can be directly translated to the condition of all SPOs contacting the test agencies separately. Although it may seem clear to divide by project, the lines of demarcation from this point become increasingly blurred and overlapping. For example: consider the confusion and wear out given the customer if each product goes to him separately, why not send just one representing all?[12,13]

The Use and Advantage of Functional Service Staffs

A functional service staff or the use of service staff authority is a staff group that carries out a particular activity for the whole organization. This

activity has been separated from line jobs and is performed on a centralized and controlled basis as a service to all line units. The use of such an arrangement implies that if a line manager requires such a service he must go through the staff unit to obtain the service, he cannot duplicate it himself.[14,15]

The functional service staff can aid in the integration of talents or specialists in a particular area for all activities. This integration takes place by cooperation, coordination, and control. This overall communication/coordination problem must be solved if specialization is to be used to advantage and like disciplines kept in contact.[16] Many organizations have answered the need for across product assistance of specialized functions by the use of service staffs, particularly in those needed by research engineers and scientists. The exact type of service will of course be highly dependent upon the need and field of activities.[17]

Beyond improving communications in a complex organization the functional service staff has perhaps the even more important job of consolidating or centralizing the specialized and functional managerial and organizational resources to achieve the maximum in

performance efficiency.[18] As functions become more complex the efficiency by which they are coordinated directly affects the economy of the operation. In general a complex line unit (such as product, project, or system) will not do as good a job in a highly specialized area as will a dedicated special unit. The economics of centralized operations make it very important that a service staff be used if at all possible. Such practices achieve economies by uniform procedures and generally more effective work.[19]

The use of staff specialization of skills of course is not new by any means. Traditional ones include financial, market research, and even R&D itself.[20] The USAF has also recognized their use in instructing the SPD in his duties. Although the SPD has complete responsibility and authority for the successful accomplishment of all matters related to his program, he must depend on service organizations to assist in his program effort. The use of SPO parent organization staffs in legal, procurement, financial matters is required.[21] Another perfect example in the same area is the use of centralized civil engineering functions. Each SPO will be assigned a civil engineer with responsibility for all system facilities planning and

acquisition. He may elect to physically colocate with the SPO if the size of the program warrants. In any case he is a direct representative (member) of the SPO parent organization civil engineering office (see Figure 2) and will receive support from the civil engineering activities.[22]

Summary

This chapter has attempted to portray some of the drawbacks to purely project oriented organizations as seen by some of the experts in the fields of management and organization theory. The problems of communication, cross-fertilization, economy, higher quality work in a special area have been highlighted since they directly correspond to some of the SPO problem areas as discussed in Chapter 4. The concept of using a specialized functionally oriented staff has been outlined as a potential for easing if not solving many of these problems. The superimposing or combination of the project structure and the subject or specialized structure appears to offer a considerable advantage over the project structure alone.[23]

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

Prior chapters of this paper have outlined the R&D test of missiles and space vehicles from the SPO parent organization point-of-view with the object to improve the efficiency with which these tests are managed. The study has discussed the importance of R&D as the basis for technological progress and the test portion of R&D as critical to the evaluation and determination of R&D hardware performance.

Conclusions

The use of the SPO/systems management approach is an elaborate and costly project oriented structure which may have many problems when applied to small programs in a limited resource environment. The lack of experienced personnel continually plagues the SPO when preparing test support request documentation. This shortage along with the fact that each SPO man rarely gets enough repetitions in jobs/tasks to become truly expert results in a generally poor test documentation product.

Communications is a second large problem area for SPOs. Communications tend to breakdown between SPOs and between members of the test team. Such a breakdown impedes the flow of vital information and causes undue friction between all concerned. The SPO must avoid this problem if it is to be successful in the long term. The use of a central-point-of-contact between the test team units, based on functional specialties was advanced as a potential addition to the project/multifunctional SPO mode of operation in an attempt to alleviate some of these inherent or possible SPO organizational structure problems. These last two areas, disadvantages of the project oriented structure and some advantages of a specialized functional staff structure were elaborated from the point of view of writers in the management and organization field of study. With these general conclusions the following recommendations are offered as possible improvements to the SPO test environment.

Recommendations

Improve SPO Communications. Improved communications appears to be a big payoff area for the SPO. Without adequate communications all tasks become more difficult than necessary. The SPO needs to improve his internal

communications to keep his people well informed not only of their own mission but that of collateral efforts in other SPOs. SPO personnel must be encouraged to seek out their "own kind" in sister SPOs to foster an interchange of information and data to insure that cross-fertilization short stops those uncommon solutions to common problems. The biggest effort in the entire communications area and the one with the most importance in the test area should go to the test team members and units. These people have too long been kept in the dark or fed bits of information in just enough quantity to keep them interested. In the author's opinion the SPO has a very bad record and name in this area. The SPO must appraise the test team as changes occur and be honest with the reasons, if any mutual trust is to build on each side. The SPO is dependent on the test support agencies for their support and they in turn, although to a lesser degree, on him for work. If this team is to really be effective each must understand the other's needs and problems and then get on with the mission of testing. It is the SPD's and each SPO division chief's responsibility to initiate and continue a program of expanded communications.

<u>Concentrate Limited SPO Manpower and Resources</u>.

With limited manpower and other resources the SPD must place his emphasis or main efforts on the things that he can do best and that cannot be delegated or passed on to others. Such areas might include engineering, design reviews, production, scheduling, and the like. On the other hand the SPD should give up routine jobs that are not really program peculiar and that can perhaps be done more efficiently by others. The SPD should not use the excuse that he cannot delegate in fear of loosing control. A central office charged with supporting all SPOs must be responsive and produce or be abolished. This will free SPO manpower to spend greater time on the critical areas of managing the acquisition of the system and to become better at it because of the additional time and reduced scope of duties.

Consolidate Small or Like SPOs Wherever Possible. SAMSO or AFSC should consider the use of one or a few large SPOs to manage several small programs particularly if the programs have a number of things in common, like launch vehicle, launch range, orbit, level of technology, etc. Such consolidations should result in additional economies from the saving of manpower, again allowing for greater specialization by personnel and potentially doing a better job because of it. Consolidated SPOs

should be more responsive to test team needs and be able to make more economical use of all assigned or used resources, the test facilities area being just one such possibility.

Increase the Use of Functional Service Staffs. SPOs and their established organization policy and management procedures should be modified to move from the traditional fractionated mode of operation to a use of special functional service staffs wherever such consolidation appears feasible and in the best interests of economy. AFSC and USAF should take action to change systems management directives, in particular AFSC Manuals 375-3 (System Program Office Manual) and 375-4 (System Program Management Procedures) to require and reaffirm this modification. Such staffs appear to be best suited to a complex, continuing job where a standardized high quality output is required and where such an output or need is common to all (or a majority) serviced units. It is not to be implied that such staffs should be set up just for the sake of setting them up, but should only be done when there is a direct payoff to the SPOs as a whole and as in the case in this study, the test team in general. To adequately perform their duties in consolidating work and as a

central-point-of-contact the functional service staff must be colocated with the SPO as a part of the SPO parent organization. This colocation will allow for the day-to-day personal contact and access to meetings and SPO personnel that is absolutely necessary if this office is to be successful. In turn for the efforts of the functional staff the SPO must be complete in its trust, support, and supplying of information to the staff office.

<u>Continue Use of the SAMSO Operational Systems Development Division</u>. It is recommended in particular that the Operational Systems Development Division in SAMSO be further expanded, as applicable, to cover as much of the test activity as possible. The use of the single or central-point-of-contact that such an office provides increases the understanding of test requirements among the test team members. This type of office can do much to increase the flow of communication between units. The test area proved a fertile area for consolidation of functions and others will possibly be equally rewarding. The centralized preparation of range test support documentation, review of test plans, review of statements of work should continue so to insure that the area of test is covered in a complete and correct

manner.

Continued study of the SPO/Systems Management Concept. The above recommendations are provided as those substantiated by the author's experience, policies already stated in SPO directives but not accepted for actual or widespread use, and the concepts derived from the management and organization field. These recommendations should be reviewed for possible application in areas other than test of space and missile systems. Also SPO parent organizations in other than the space and missiles field (i.e. aircraft or electronic systems) should be studied for possible use of additional functional staffs as an adjunct to their present SPO and line/staff organization arrangements. In any case the subject of this report and its general thesis should continue to be studied to ensure that systems management progresses and stays an economically competitive concept of management.

FOOTNOTES

Chapter I

1. Air Force Systems Command Manual 375-4, *System Program Management Procedures* (Andrews AFB, Washington, D.C.: AFSC, 31 May 1966), par. 25, p. 12.

2. Anne M. Jonas, "New Dimensions in Soviet Strategy," *Air Force and Space Digest*, LI, No. 1 (January 1968), p. 23.

3. "Air Force Systems Command," *Air Force and Space Digest*, LI, No. 9 (September 1968), p. 103.

4. Fremont E. Kast and James E. Rosenzweig, *Science, Technology, and Management* (New York: McGraw Hill Book Co., Inc., 1963),pp. 21-26.

Chapter II

1. Air Force Regulation 80-14, *Test and Evaluation of Systems, Subsystems, and Equipment* (Washington: Department of the Air Force, 24 February 1967), par. 2.

2. Air Force Regulation 80-1, *Air Force Research and Development* (Washington: Department of the Air Force, 8 April 1966, Revision 1, 26 July 1968), par. 1,2.

3. Air Force Regulation 23-18, *Office of Aerospace Research* (Washington: Department of the Air Force, 31 January 1968), par. 1.

4. Air Force Regulation 57-1, *Policies, Responsibilities, and Procedures for Obtaining New and Improved Operational Capabilities* (Washington: Department of the Air Force, 17 June 1966), par. 3.

5. Air Force Regulation 80-1, *op. cit.*, par. 3.

6. "Office of Aerospace Research," Air Force and Space Digest, LI, No. 9 (September 1968), pp. 162-163.

7. Air Force Regulation 80-14, op. cit., par. 2.

8. Ibid., par. 3.

9. Ibid., par. 5.

Chapter III

1. Kast, op. cit., p. 336.

2. David I. Cleland, "Understanding Project Management," Manage. Vol. 19, No. 9 (September 1967), p. 34.

3. Made up of Conceptual, Definition, Acquisition, and Operational Phases.

4. Air Force Regulation 375-1, Management of System Programs (Washington: Department of the Air Force, 25 November 1963), par. 2m(1).

5. Air Force Systems Command 23-43. System Program Office (Mission) (Andrews AFB, Washington, D.C.: AFSC, 28 May 1965, revised to 21 September 1965), par. 2.

6. Ibid., par. 4.

7. Air Force Systems Command Regulation 23-20, AFSC Systems Divisions (Mission) (Andrews AFB, Washington D.C.: AFSC, 21 September 1962, revised to 28 May 1965), p. 24.

8. Air Force Regulation 375-4, System Program Documentation (Washington: Department of the Air Force, 25 November 1963, Revision 1, 28 August 1968), par. 5d(3) and p. 13(Atch 1).

9. Air Force Systems Command Manual 375-3, System Program Office Manual (Andrews AFB, Washington, D.C.: AFSC, 15 June 1964), p. 51.

10. Air Force Regulation 80-14, op. cit., par. 3g.

11. Air Force Systems Command Manual 375-3, *op. cit.*, p. 53.

12. *Ibid*.

13. Space and Missile Systems Organization RCS: 1-SYS-03, *Organization and Functions Chart Book* (Los Angeles AFB, Ca.: SAMSO, corrected to 22 August 1968), p. ii.

14. Air Force Systems Command Regulation 23-1, *Space and Missile Systems Organization (Mission)* (Andrews AFB, Washington, D.C.: AFSC, 14 February 1968), par. 2.

15. Air Force Systems Command Manual 375-4, *op. cit.*, p. 4.

16. Air Force Systems Command Manual 375-3, *op. cit.*, p. 13.

17. *Ibid*., p. 15.

18. Space and Missile Systems Organization RCS: 1-SYS-03, *op. cit.*, pp. 7-4, 7-5.

19. Air Force Systems Command Regulation 23-13, *Air Force Eastern Test Range (Mission)* (Andrews AFB, Washington, D.C.: AFSC, 2 January 1969), par. 1.

20. Air Force Systems Command Regulation 23-14, *Air Force Western Test Range (Mission)* (Andrews AFB, Washington, D.C.: AFSC, 2 January 1969), par. 1.

21. Air Force Systems Command Regulation 26-36, *AFSC Centers/Ranges* (Andrews AFB, Washington, D.C.: AFSC, 18 June 1965, revised to 4 May 1966), p. 7(Atch 2).

Chapter IV

1. Kast, *loc. cit*.

2. General Bernard A. Schriever, "The Role of Management in Technological Conflict," *Air University Quarterly Review*, XIV (Winter-Spring 1962-1963), p. 26.

3. Captain James L. Russell, "Systems Management in the Air Force: Its Effect on Research and Development Organizations" (unpublished Air Command and Staff College thesis, 1966), pp. 13-14.

4. Lt. Colonel William H. Spillers, "Categories II and III System Test and Evaluation - The Need for Detailed Guidance and Direction" (unpublished Air War College thesis, 1966), p. 184.

5. Ibid., p. 182.

Chapter V

1. Joseph A. Litterer, The Analysis of Organizations (New York: John Wiley and Sons, Inc., 1965), p. 157.

2. James G. March and Herbert A. Simon, Organizations (New York: John Wiley and Sons, Inc., 1958), p. 25.

3. Ibid.

4. Ibid., p. 29.

5. Litterer, op. cit., p. 176.

6. Alexander O. Stanley and K. K. White, Organizing the R&D Function (American Management Assn., Inc., 1965), pp. 33-34.

7. Ibid., pp. 33-34, 37.

8. Thomas Moranian, The Research and Development Engineer as Manager (New York: Holt, Rinehart and Winston, 1963), p. 91.

9. John S. Baumgartner, Project Management (Homewood, Illinois: Richard D. Irwin, Inc., 1963), pp. 88-91.

10. Leonard J. Kazmier, Principles of Management (New York: McGraw Hill Book Co., 1964), p. 77.

11. Litterer, loc. cit.

12. *Ibid*.

13. Kazmier, *loc. cit.*

14. *Ibid*., pp. 97-98.

15. Richard A. Johnson, Fremont E. Kast and James E. Rosenzweig, *The Theory and Management of Systems* (New York: McGraw Hill Book Co., Inc., 1963), pp. 46-47.

16. Raymond Villers, *Research and Development: Planning and Control* (New York: Financial Executive Research Foundation, Inc., 1964), pp. 16-17.

17. *Ibid*., pp. 19, 132.

18. Kast, *op. cit*., p. 337.

19. Kazmier, *op. cit*., p. 98.

20. Johnson, *op. cit*., p. 100.

21. Air Force Systems Command Manual 375-3, *op. cit*., p. 65.

22. *Ibid*., p. 77.

23. Stanley, *op. cit*., p. 38.

BIBLIOGRAPHY

Books

Baumgartner, John S. Project Management. Homewood, Illinois: Richard D. Irwin, Inc., 1963

Johnson, Richard A., Fremont E. Kast and James E. Rosenzweig. The Theory and Management of Systems. New York: McGraw Hill Book Co., Inc., 1963.

Karger, Delmer W. and Robert G. Murdick. Managing Engineering and Research. New York: The Industrial Press, 1963.

Kast, Fremont E. and James E. Rosenzweig. Science, Technology, and Management. New York: McGraw Hill Book Co., Inc., 1963.

Kazmier, Leonard J. Principles of Management. New York: McGraw Hill Book Co., 1964.

Koontz, Harold and Cyril O'Donnell. Principles of Management. New York: McGraw Hill Book Co., Inc., 1964.

Litterer, Joseph A. The Analysis of Organizations. New York: John Wiley and Sons, Inc., 1965.

Litterer, Joseph A. Organizations: Structure & Behavior. New York: John Wiley and Sons, Inc., 1964.

March, James G., and Herbert A. Simon. Organizations. New York: John Wiley and Sons, Inc., 1958.

Massie, Joseph L. Essentials of Management. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1964.

Moranian, Thomas. The Research and Development Engineer as Manager. New York: Holt, Rinehart and Winston, 1963.

Stanley, Alexander O. and K.K. White, Organizing the R&D Function. American Management Assn., Inc., 1965.

Villers, Raymond. Research and Development: Planning and Control. New York: Financial Executive Research Foundation, Inc., 1964.

Articles and Periodicals

"Air Force Systems Command," Air Force and Space Digest, LI, No. 9 (September 1968), 103.

Cleland, David I. "Understanding Project Management," Manage, Vol. 19, No. 9 (September 1967), 34.

Jonas, Anne M. "New Dimensions in Soviet Strategy," Air Force and Space Digest, LI, No. 1 (January 1958), 23.

"Office of Aerospace Research," Air Force and Space Digest, LI, No. 9 (September 1968), 162-163.

Schriever, General Bernard A. "The Role of Management in Technological Conflict," Air University Quarterly Review, XIV (Winter-Spring 1962-1963), 26.

Official Documents

Air Force Regulation 23-18, Office of Aerospace Research. Washington: Department of the Air Force, 31 January 1968.

Air Force Regulation 57-1, Policies, Responsibilities, and Procedures for Obtaining New and Improved Operational Capabilities. Washington: Department of the Air Force, 17 June 1966.

Air Force Regulation 80-1, Air Force Research and Development. Washington: Department of the Air Force, 8 April 1966, Revision 1, 26 July 1968.

Air Force Regulation 80-14, Test and Evaluation of Systems, Subsystems, and Equipment. Washington: Department of the Air Force, 24 February 1967.

Air Force Regulation 375-1, Management of System Programs. Washington: Department of the Air Force, 25 November 1963.

Air Force Regulation 375-4, System Program Documentation. Washington: Department of the Air Force, 25 November 1963, Revision 1, 28 August 1968.

Air Force Systems Command Manual 375-3, System Program Office Manual. Andrews AFB, Washington, D.C.: AFSC, 15 June 1964.

Air Force Systems Command Manual 375-4, System Program Management Procedures. Andrews AFB, Washington, D.C.: AFSC, 31 May 1966.

Air Force Systems Command Regulation 23-1, Space and Missile Systems Organization (Mission). Andrews AFB, Washington, D.C.: AFSC, 14 February 1968.

Air Force Systems Command Regulation 23-13, Air Force Eastern Test Range (Mission). Andrews AFB, Washington, D.C.: AFSC, 2 January 1969.

Air Force Systems Command Regulation 23-14, Air Force Western Test Range (Mission). Andrews AFB, Washington, D.C.: AFSC, 2 January 1969.

Air Force Systems Command Regulation 23-20, AFSC Systems Divisions (Mission). Andrews AFB, Washington, D.C.: AFSC, 21 September 1962, revised to 28 May 1965.

Air Force Systems Command Regulation 23-43, System Program Office (Mission). Andrews AFB, Washington, D.C.: AFSC, 28 May 1965, revised to 21 September 1965

Air Force Systems Command Regulation 26-36, AFSC Centers/Ranges. Andrews AFB, Washington, D.C.: AFSC, 18 June 1965, revised to 4 May 1966.

Space and Missile Systems Organization Manual 80-1, Flight Test Documentation Manual. Los Angeles AFS, California: SAMSO, 2 January 1968, revised to 20 May 1968.

Space and Missile Systems Organization RC3:1-SYS-03, Organization and Functions Chart Book. Los Angeles AFS, California: SAMSO, corrected to 22 August 1968.

Unpublished Material

Russell, Captain James L. "Systems Management in the Air Force: Its Effect on Research and Development Organizations." Unpublished Air Command and Staff College thesis, Air University, Maxwell AFB, Alabama, 1966.

Spillers, Lt. Colonel William H. "Categories II and III System Test and Evaluation - The Need for Detailed Guidance and Direction." Unpublished Air War College thesis, Air University, Maxwell AFB, Alabama, 1966.